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Estimation of sex of Egyptian population by 3D computerized tomography of the pars petrosa ossis temporalis

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Abstract The pars petrosa ossis temporalis has been studied for the purpose of sex estimation in many cadaveric studies. Since several studies have demonstrated that discriminant function equations used to determine the sex of a skeleton are population specific, the purpose of this study was to evaluate the capability of computerized tomography of temporal bone of living individuals to estimate the sex from measuring the lateral angle of internal acoustic canal meatus and drive similar equation for the size of the angle. Multidetector computerized tomography (MDCT) of the temporal bone was done to 120 patients (59 females and 61 males) to measure the lateral angle size. The mean angle is greater in females (50.34 ± 6.178) than males (42.39 ± 5.77). Measurements of 37.187° and lesser were 83.6% specific for males and measurements higher than 37.187° were 77.96% specific for females. Finally, it is concluded that the petrous portion of temporal bone is useful for sex estimation in Egyptian population.

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1. Introduction

Sex differentiation using human skeletal parts is of a particular importance not only for the archeologically-oriented anthropologist, but also especially so in forensic medicine and above all in the identification of individuals.[1]

Several factors influence the accuracy of sex estimation from adult skeletal remains. First, many of the anatomical differences between the skeletal elements of males and females are not significantly pronounced. In terms of skeletal dimensions, males and females differ only by approximately 8%.[2]

The second factor that influences the accuracy of sex estimation is the validity of traditional morphological and metric approaches to sex estimation that relies on a high degree of

preservation and skeletal completeness, specifically of sexually dimorphic element of the skull and pelvis.[3]

Although DNA analysis techniques have been increasingly utilized for sex estimation, the methods based on anatomic measurement may still find a role in instances where DNA analysis is not readily available and the integrity of the corpse needs to be preserved.[4]

A high diagnostic value in sex estimation can be attributed to those skeletal parts that are usually well preserved. These parts include the skull base, and in particular the petrous portion of temporal bone (pars petrosa ossis temporalis), which is still preserved in corpses destroyed by fire.[5]

Advances in technologies such as computed tomography (CT) scanning, Magnetic Resonance Imaging (MRI), computer based anthropometry, and biochemical analyses are answering questions that could not have been answered 10 years ago, and are significantly improving the accuracy of skeletal analyses especially in sex estimation.[6]

Discriminant function analysis has become important in forensic anthropology. If a measurement on a bone is suspected to be sexually dimorphic, it is suspected to discriminant function analysis.[7]

Lateral angle (LA) of the internal acoustic canal meatus is a measurement that has been evaluated in prior studies on cadavers for sexing the temporal bone, with favorable results.[8] Therefore, the aim of this study was to assess the sexual dimorphism of the lateral angle of the internal acoustic canal meatus as measured on computed tomography (CT) of the temporal bone in living subjects and drive discriminant function equations that would be useful in the estimation of sex in Egyptian population.

2. Subjects and methods

2.1. Subjects

One hundred and twenty patients who needed temporal bone high resolution CT for ear-related complaints, such as otitis, hearing loss and vertigo were evaluated. There were 59 females (age range: one month–65 year, mean 29.73 ± 2.33) and 61 males (age range: 1–70 year, mean 27.77 ± 1.79). Imaging studies were done as a part of clinical work up for ear problems, so no need for informed consent or approval from hospital research Ethics Committee. Any patient with congenital anomalies and fractures of the temporal bone was excluded from the study.

2.2. MDCT protocol for image acquisition

CT examinations were done on 16-slice machine (GE bright speed, GE health care, USA). Examinations were done in Minia University Hospital. Images were taken through the temporal bone with the following parameters: 120 KVp, 100 mAs, a helical pitch of 0.562:1, 0.8 s scan time, 16×0.625 mm detector configuration, 8.8 s total exposure time, 0.625 mm helical slice thickness, 0 tilt and 0.625 mm reconstruction interval with a small field of view (FOV). Images were reconstructed using bone algorithm. Images were transferred to advanced workstation (AW volume share 2) with commercially available software that allows angle measurement.

Figure 1 Axial CT at the level of the incudomaleal joint shows the bony ossicles (long arrow) and internal auditory canal meatus (short arrow).

2.3. Measurement of the lateral angle of internal acoustic canal meatus

Measures were taken in the axial images in which the apex of the internal acoustic canal was displayed most pointed, and this was the image just next to the one best shows the incudomaleal joint (ice cream cone) (Fig. 1). The angle (Fig. 2) was taken between two lines, the first one connected the anterior and posterior lips of the canal, the second line connected the anterior lip of the internal acoustic canal with the most anterior point of the anterior wall of the canal. All measures were taken on the right side by the same radiologist.

2.4. Statistical analysis

The data were analyzed using SPSS statistical package version 16. Means and standard deviations were obtained for LA size. Correlation between age and LA was tested using Pearson's correlation test. After using a student-*t*-test to establish that a significant difference exists ($P \leqslant 0.05$) between the male and female LA size, univariate discriminant function analysis was performed. From these analyses, coefficients and constants were obtained for derivation of discriminant function scores and equations. Then, the cut point is derived which is the summation of discriminant function scores of males and females. For example, if the mean value for a measurement is greater than the male mean value and the discriminant score is greater than the cut point, the bone is classified as female.

3. Results

Measurements of lateral angle size in this study revealed that females presented with significantly greater ($P < 0.01$) mean

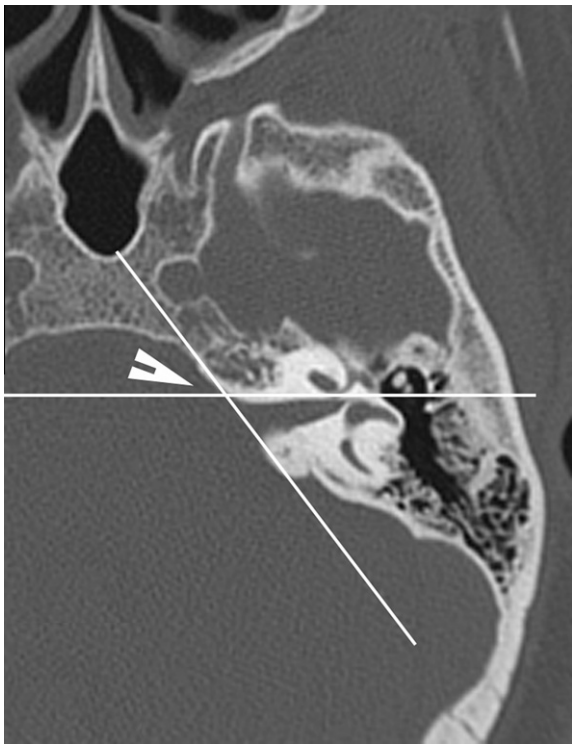

Figure 2 Axial CT images at a level next to Fig. 1 shows the measured lateral angle (arrowhead).

values than males (Table 1), this indicating the presence of significant sexual dimorphism in the lateral angle of internal acoustic canal meatus on examining the Egyptians temporal bone by CT scan.

Correlation between LA size and age in males and females, in which there was a significant moderate correlation between age and LA in females ($r = 0.55$ and $P = 0.003$), while there was no correlation in males ($r = 0.06$ and $P = 0.31$). The overall correlation was borderline significant mild correlation ($r = 0.25$ and $P = 0.04$).

When the sub-adult subjects were concerned, the LA did not show a significant difference between sexes. There were 32 subjects $\leqslant$than 18 years. In this group, there were 10 females (mean age 18.2 ± 5.23, range: one month–17), and 22 males (mean age 12.3 ± 4.3, range: one year–18). The mean LA in females was 53.82 ± 5.82, range: 41.2–60.5, and in males was 50.22 ± 5.6; range: 36–50.2. The difference was not significant statistically ($P = 0.09$). For females, the mean LA was higher for patients up to 18 (53.82 ± 5.82) than those older than 18 (51.92 ± 6.22). The difference was statistically not significant ($P = 0.06$). For males, the mean LA was higher for patients up to age 18 (50.22 ± 5.6), than those older than 18 (47.89 ± 6.22). The difference was statistically not significant ($P = 0.08$).

Table 2 Sex estimation from the measurement of LA size.

Observed		Predicted		
		Sex		Percentage correct (%)
		Male	Female	
Sex	Male (61)	51	10	83.6
	Female (59)	13	46	77.96
	Overall percentage			80.78

By univariate discriminant function analysis, the percentage of accuracy of LA size in females was 77.96%, while, in males it was 83.6%, with a mean of 80.78% (Table 2).

From univariate discriminant function (df) coefficient, df value for males and females can be calculated as follows:

$$\mathbf{df} = \mathbf{standard\ coefficient(SC)} \times \mathbf{LA\ mean}$$

$$\mathrm{df(males)} = 0.802 \times 42.395 = 34.001$$

$$\mathrm{df(females)} = 0.802 \times 50.342 = 40.374$$

$$\mathbf{Cut\ point} = \mathrm{df(males)} + \mathrm{df(females)}/2 = 34.001 + 40.374/2 = 37.187$$

If the df score is $\geqslant$37.187, the individual is considered female and if it is $<$37.187, the individual is considered male.

4. Discussion

The ability of the temporal bone CT to produce the results of direct anatomic measurement of the LA may help forensic science investigators in their research for determining the sex of a body or its parts.[3]

The petrous portion of temporal bone has been studied for the purpose of sex estimation in a number of cadaveric studies. Since the petrous part is very sturdy due to its dense compact nature, it is likely to preserve its integrity even in most cases of head trauma (with the exception of direct trauma to the temporal bone).[1,4,8,9]

This present study used CT for sexing the temporal bone in living subjects by measuring the LA of the internal acoustic canal meatus. However, this study has limitations such as our subjects were patients with ear problems and not normal population. This is probably not very likely to introduce a significant source of error and it is not ethical to study a truly normal population by CT, especially children, because of radiation exposure. The second limitation is the small number of sub-adult subjects precluded evaluation of the LA as measured on CT in determining sex in this subgroup.

The existence of significant sexual dimorphism in the size of the LA of internal acoustic canal meatus has been confirmed by the present study. Thus, the discriminant functions derived in the present study will be of considerable utility to investigators in the forensic science since the measurement used involve

Table 1 Descriptive statistics of the LA size for Egyptian population.

Variable	Male					Female					*t*-Value	*P* value
	Number	Min.	Max.	Mean	S.D.	Number	Min.	Max.	Mean	S.D.		
LA	61	34.5	57.8	42.39	5.77	59	38.9	61.2	50.34	6.178	6.46	0.00*

* *P* value is significant when $P < 0.01$.

a preservationally favored portion of the skeleton (petrous portion of temporal bone).

The mean values and standard deviations in this study are similar to those reported from cadaveric study of Noren et al.[4] and the living study of Akansel et al.[3] for both females (50.34 ± 6.178; range: 38.9–61.2 in our study and 48.2 ± 6.8; range: 35–65 in the cadaveric study while it was 45.5 ± 7.1; range 30–68 in the living study) and males (42.39 ± 5.77; range: 34.5–57.8 in our study while it was 40 ± 6.4; range: 25–65 in the cadaveric study and 41.6 ± 6.7; range: 30–60 in the living study of Akansel et al.[3]

Independent samples *t*-test was done for all males and females samples, the results revealed that there was a significant difference between males and females LA size of internal acoustic canal meatus in Egyptian population (females had greater LA than males). These results are agreed with the study done by Akansel et al., Noren et al.[3,4]

The different width–height relationship of the temporal bones might serve as an anatomical explanation for the observed sexual dimorphism.[10] In addition, broader male skull, in particular the cranial base is responsible and the location of internal acoustic canal meatus relative to the length and width of the skull[11] and petrous bone morphology is different in males than females.[12]

The age-related nature of the sex differences in the petrous part of the temporal bone has been observed in a cadaveric study by Wahi and Graw.[1] The results of our study detect a significant moderate correlation between age & LA in females and no correlation in males. The difference of male & female data in their relationship with age can be explained by the wide age range or distribution within the sample, the ethnicity, the number of adult versus the subadult persons.[12]

Univariate discriminant function analysis revealed that LA of internal acoustic canal meatus can be used for sex estimation of the petrous portion of temporal bone in Egyptians, the accuracy was 80.78% (83.6% in males and 77.96% in females). These results are in contrast with the study done by Graw et al.[8] in which their study revealed that the accuracy was 67.9% (73.3% in males and 62.5% in females).

In contrast with earlier studies published in the German literature,[1,13] the authors found that a demarking point of 45° provided the best discrimination between the sexes, with females having an angle size greater than 45, where the angle size in males was less than 45°. The present study revealed that a cut point of 37.187° provided the best discrimination between males and females (male < 37.187° < female).

Finally, this study has shown that the LA of internal acoustic canal meatus of Egyptians is sexually dimorphic and the use of a multislice CT scanner of the petrous portion of temporal bone could theoretically allow for more precise measurement.

5. Conclusion & recommendations

Computed tomography (CT) scanning is a non- destructive tool for imaging the petrous portion of temporal bone. The presented methodology shows promising results for sex estimation based on the size of lateral angle of internal acoustic canal meatus. So, it is recommended that the equation derived from this study should be used with caution for estimation of sex of Egyptian population. Also, it is recommended to make future studies with modification of this technique for MRI that may help to obtain more information from a large number of subjects from younger age. Optimization of scanning measuring techniques as well as increased numbers of samples can therefore be a subject of further investigation.

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Ethical approval

No ethical approval is required.

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